

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE 26th December, 1994	3. REPORT TYPE AND DATES COVERED Final, August 1991-October 1994		
4. TITLE AND SUBTITLE Effect of mild hydrostatic pressure on red blood cells			5. FUNDING NUMBERS N00014-91-J-1880	
6. AUTHOR(S) Professor Saul Yedgar				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Hebrew University, Jerusalem, Israel 91904			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Dr. Constance Oliver, Office of Naval Research, 800 North Quincy Street, Arlington, VA 22217-5660.			10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES				
12a. DISTRIBUTION/AVAILABILITY STATEMENT Unlimited			12b. DISTRIBUTION CODE	

DTIC
ELECTE
FEB 13 1995
S G D

13. ABSTRACT (Maximum 200 words)

We studied the effect of physiological levels of hydrostatic pressure, such as that applied in diving or hyperbaric treatment, on 1. flow (rheological) properties and 2. membrane fluidity and morphology of red blood cells (RBC). It was found that application of such pressure 1. Enhances the aggregability of RBC (studied by a computerized image analysis which was developed for this purpose), and higher than normal flow rate was required to disperse the cells. 2. Reduces RBC membrane fluidity (studied by fluorescence anisotropy of lipid probes and tryptophan), and changes the cell morphology (studied by scanning electron microscopy) from normal discocytes to stomatocytes. Physical and rheological properties of RBC, as well as their shape, play a major role in blood flow and in their cellular-biochemocal functions. Thus, the alterations in RBC reported here may be pertinent to the microcirculatory and physiological distorters observed among humans subjected to elevated pressure.

14. SUBJECT TERMS Hydrostatic pressure, red blood cells aggregation, membrane fluidity and morphology, microcirculation diving, hyperbaric treatment.			15. NUMBER OF PAGES 3
			16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

19950203 271

GENERAL INSTRUCTIONS FOR COMPLETING SF 292

The Report Documentation Page (RDP) is used in announcing and cataloging reports. It is important that this information be consistent with the rest of the report, particularly the cover and title page. Instructions for filling in each block of the form follow. It is important to *stay within the lines* to meet *optical scanning requirements*.

Block 1. Agency Use Only (Leave blank).

Block 2. Report Date. Full publication date including day, month, and year, if available (e.g., 1 Jan 88). Must cite at least the year.

Block 3. Type of Report and Dates Covered. State whether report is interim, final, etc. If applicable, enter inclusive report dates (e.g., 10 Jun 87 - 30 Jun 88).

Block 4. Title and Subtitle. A title is taken from the part of the report that provides the most meaningful and complete information. When a report is prepared in more than one volume, repeat the primary title, add volume numbering, and include subtitle for the specific volume. On classified documents enter the title classification in parentheses.

Block 5. Funding Numbers. To include contract and grant numbers; may include program element number(s), project number(s), task number(s), and work unit number(s). Use the following labels:

C - Contract	PT - Project
G - Grant	TA - Task
PE - Program Element	WU - Work Unit
	Accession No.

Block 6. Author(s). Name(s) of person(s) responsible for writing the report, performing the research, or credited with the content of the report. If editor or compiler, this should follow the name(s).

Block 7. Performing Organization Name(s) and Address(es). Self-explanatory.

Block 8. Performing Organization Report Number. Enter the unique alphanumeric report number(s) assigned by the organization performing the report.

Block 9. Sponsoring/Monitoring Agency Name(s) and Address(es). Self-explanatory.

Block 10. Sponsoring/Monitoring Agency Report Number. (If known)

Block 11. Supplementary Notes. Enter information not included elsewhere such as: Prepared in cooperation with...; Trans. of...; To be published in... When a report is revised, include a statement whether the new report supersedes or supplements the older report.

Block 12a. Distribution/Availability Statement. Denotes public availability or limitations. Cite any availability to the public. Enter additional limitations or special markings in all capitals (e.g., NOFORN, REL, ITAB).

DDP - See DoDD 5230.24, "Distribution Statements on Technical Documents"

DOE - See authorities.

NASA - See Handbook NHB 2200.2.

NTIS - Leave blank.

Block 12b. Distribution Code.

DDP - Leave blank.

DDP - Enter DDP distribution categories from the Standard Distribution for Unclassified Scientific and Technical Reports.

NASA - Leave blank.

NTIS - Leave blank.

Block 13. Abstract Included (brief (At minimum 200 words) summary of the most significant information reported in the report).

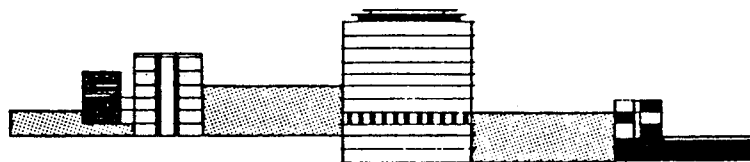
Block 14. Subject Terms. Key words or phrases identifying major subjects in the report.

Block 15. Number of Pages. Enter the total number of pages.

Block 16. Price Code. Enter appropriate price code (NTIS only).

Blocks 17-18. Security Classifications. Self-explanatory. Enter the U.S. Security Classification in parentheses and U.S. Security Regulations (e.g., UNCLASSIFIED). If foreign classification is used, reference to foreign classification on the top and bottom of page.

Block 20. Limits of Abstract. This block must be completed regardless of limits to the abstract. Enter either UNL (unlimited) or SAR (same as report). An entry in this block is necessary if the abstract is to be limited. If blank, the abstract is assumed to be unlimited.



בית הספר לרפואה של האוניברסיטה העברית והדסה ירושלים
THE HEBREW UNIVERSITY - HADASSAH MEDICAL SCHOOL, JERUSALEM 91120

Professor Saul Yedgar
Department of Biochemistry

Tel: 972-2-439218; 758306 (w); 520159 (h).
Fax: 972-2-757379; 784010.
E-mail: YEDGAR@MD2.HUJI.AC.IL.

FINAL REPORT, Grant No. N00014-91-J-1880.

EFFECT OF HYDROSTATIC PRESSURE ON RED BLOOD CELLS.

The following studies have been performed:

1. Monitoring of red blood cell aggregability in a flow-chamber by computerized image analysis: A system for direct observation and video recording of red blood cells (RBC) under flow, and computerized analysis of their aggregability was constructed. A narrow-gap flow-chamber was designed, in which a blood sample is subjected to controllable flow. Software was developed to provide the RBC aggregate size distribution at different shear stresses. From the size distribution curves the average or median size (or any other percentile) of the aggregate population as a function of shear stress, as well as the shear stress required for complete disaggregation, can be derived. The kinetics of spontaneous aggregation, in stasis, from singly dispersed cells, as well as the disaggregation kinetics at varying shear stress, can be derived from temporal monitoring of the cells' images. This system provides quantitative measures of RBC aggregability from direct visual monitoring of the aggregation and disaggregation processes. This study is described in detail in **Reference 1**.

2. Monitoring of erythrocyte aggregate morphology under flow by computerized image analysis: The morphology of red blood cell (RBC) aggregates was studied by direct visualization of RBC aggregation at different flow conditions in a computerized image analyzer. The aggregate morphology is expressed by an Aggregate Shape Parameter (ASP), defined as the ratio of the aggregate projected area to its square perimeter. Aggregation was induced by either dextran-70 (m.w. 70,000) or dextran-500 (m.w. 500,000), and compared to that in plasma. It was found that the aggregate morphology is characteristic of the aggregating agent - in dextran-500 the RBC form rouleau aggregates as in plasma, while in dextran-70 they form clusters. In each system, while maintaining the overall typical morphology, the ASP decreases (i.e. the aggregate becomes longer) as the aggregate size is increased. The distribution of the ASP as a function of the aggregate size remains unchanged when the aggregate size is changed by modulation of the dextran concentration or the shear stress. Stretching of a rouleau aggregate by application of shear stress is reflected by a corresponding change in the ASP. It is suggested that the ASP is characteristic of the intercellular interactions. A theoretical model is proposed for evaluation of the deviation of aggregate shape from that of the rouleau structure. This study is described in detail in **Reference 2**.

3. Red blood cell aggregability is enhanced by physiological levels of hydrostatic pressure: The effect of hydrostatic pressure at physiological levels, such as that applied in diving or hyperbaric treatment (up to atm), on the aggregability of rat and human red blood cells (RBC) (i.e. their capability to form aggregates) was studied using the computerized image analysis system described above. The aggregate size distribution was determined under ambient pressure following application of hydrostatic pressure for various durations up to two hours. It was found that RBC aggregability markedly increases, up to three-fold, as the pressure which had been applied was increased. Accordingly, higher shear stress is required for dispersing the aggregates of pressure-treated RBC than those of untreated cells. The median size of human RBC aggregates was about three times higher than that of rat RBC, and this ratio was maintained following pressure treatment. RBC aggregability is a major determinant in blood flow, especially in the microcirculation. Pressure at the levels used in this study occurs in physiological states such as hyperbaric treatment or diving. The enhanced aggregability induced by application of such pressure implies that blood flow in microvessels might be altered under conditions associated with elevated hydrostatic pressure. This study is described in detail in **Reference 3**.

4. Membrane fluidity and shape of human red blood cells are altered by physiological levels of hydrostatic pressure: In this study we investigated the effect of hydrostatic pressure at physiological levels, as noted above, on human red blood cell (RBC) membrane fluidity and morphology. Membrane fluidity was determined by fluorescence depolarization (FA) of lipid probes, mainly diphenyl hexatriene (DPH) and of tryptophan, as well as by energy transfer from the tryptophan to the lipid probes, in ghosts prepared prior to or after application of pressure to intact RBC. The morphology of intact RBC, prior to or after application of pressure, was evaluated by scanning electronmicroscopy. It was found that 1. The FA of DPH was increased as a function of the pressure applied and the duration of the treatment. At 15 atm the FA increased by 50%, reaching a plateau after 60 min of application of pressure. 2. Increased FA, to various extents, was observed also with lipid probes which reside in the membrane lipid core, but not with probes which monitor the polar/apolar phospholipid interface or the cell surface. 3. The same treatment increased tryptophan FA by about 20%. 4. Tryptophan energy transfer to lipid probes which resides in the lipid core was increased to various degrees, which were related to the increased in FA of these probes. 5. Following application of 15 atm for 1 hour more than 60% of the RBC changes their shape from discocytes to stomatocytes. These results demonstrate that physiological levels of hydrostatic pressure, such as that applied in diving or hyperbaric treatment, might reduce the membrane fluidity of RBC and alter their morphology. RBC membrane fluidity and shape play an important role in and cellular rheological functions. Thus, the pressure-induced alterations in RBC properties might be pertinent to the microcirculatory disorders observed in humans subjected to elevated hydrostatic pressure. This study is described in detail in **Reference 4**.

PUBLICATIONS:

1. Chen,S., Barshtein,G. Gavish,B., Mahler,Y., Yedgar,S. Monitoring of red blood cell aggregability in a flow-chamber by computerized image analysis.
Clin. Hemorheology, 14:497-508, 1994.
2. Chen,S., Gavish,B., Mahler,Y., and Yedgar,S. Monitoring of erythrocyte aggregate morphology under flow by computerized image analysis.
Biorheology, in press.
3. Chen, S., Gavish,G., Barshtein,G., Mahler,Y., and Yedgar,S. Red blood cell aggregability is enhanced by physiological levels of hydrostatic pressure.
Biochim. et Biophys. Acta, 1192:247-252, 1994.
4. Barshtein,G., Bergelson,L., Dagan,A., Gratton,E., Yedgar, S.Membrane fluidity and shape of human red blood cells are altered by physiological levels of hydrostatic pressure.
Submitted for publication.

Accession For	
NTIS	CRA&I <input checked="checked" type="checkbox"/>
DTIC	TAB <input type="checkbox"/>
Unannounced <input type="checkbox"/>	
Justification _____	
By _____	
Distribution / _____	
Availability Codes	
Dist	Avail and/or Special
A-1	